Year 1 (July 1, 2008 – June 1, 2009) Progress Report:

Improved Microwave Precipitation Retrieval over Land from TRMM through GPM Era

Report prepared by:

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Project Summary and Objectives

If the Global Precipitation Measurement Mission (GPM) is to meet its requirement of global 3-hourly precipitation, the use of sounders such as AMSU will likely be needed. This project utilizes the “traditional” imager channels in conjunction with high frequency observations from AMSU and SSMIS, cloud resolving models and advanced radiative transfer models to:

(1) Study the effects of hydrometeors on the 10-183 GHz radiances and utilize them to improve the current Bayesian precipitation retrieval scheme (e.g., GPROF). Focus will be on cold season precipitation systems (e.g., stratiform rain and snowfall) since the present scheme has focused only on tropical rainfall systems.

(2) Investigate the potential of incorporating microwave sounding channels (50-60 GHz and 183 GHz) to the hydrometeor profile retrieval.

(3) Improve the current GPROF “surface screening” to remove ambiguity between precipitation and other surface signatures that resemble precipitation through the use of innovative methods such as dynamic land surface data sets available from ancillary data sets (i.e., NWP assimilation fields, emerging emissivity products, etc.).

Year 2 Progress

Some of the key scientific questions addressed during the second year of this project include:

- Is there a way to improve upon the warm season bias in the current TRMM 2A12 rainfall over land product?

- Are there ways to better characterize the land surface within the satellite FOV?

- Can we detect light rain and snowfall signals over land from satellite measurements?

- If so, what are the characteristics of these precipitation systems and what will we be able to measure with PMM/GPM from space?

Fundamental to these questions are some other key issues to consider:

- What are the deficiencies in the current 2A12 rain over land algorithm?

- What are the microphysical properties of snow (size, density, shape, and number) to radiative properties (scattering and absorption)?

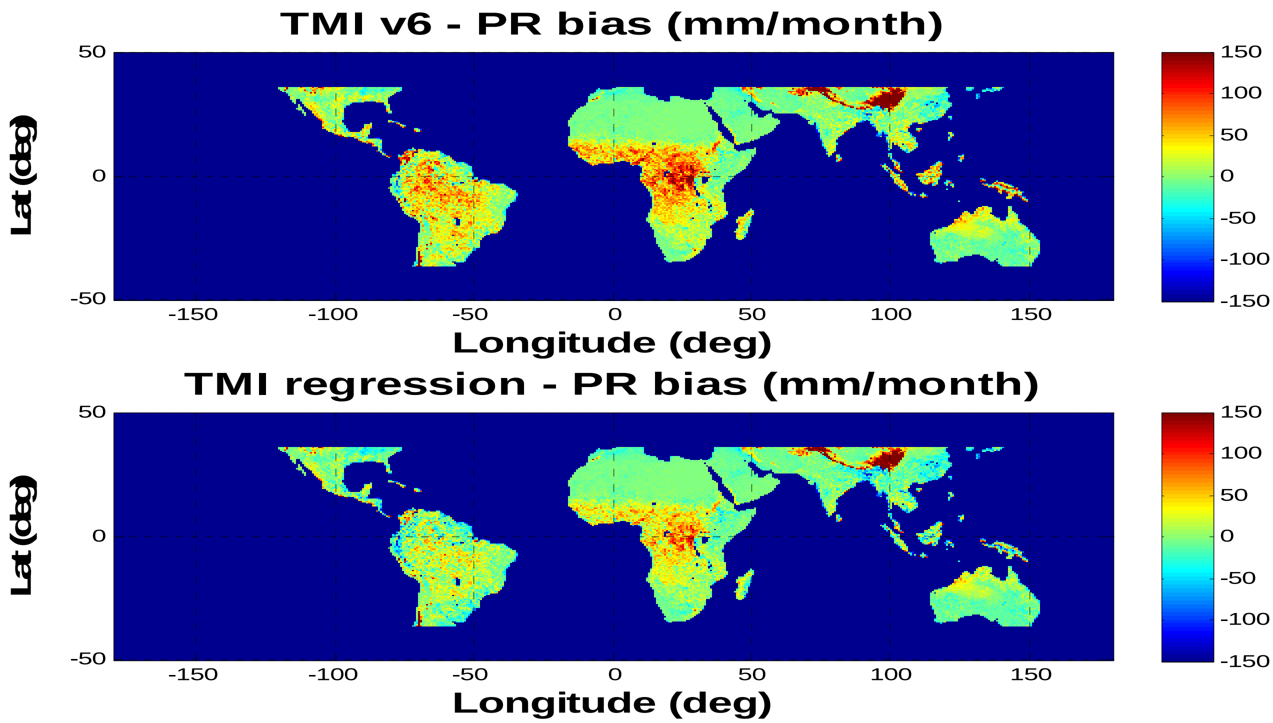
- What is the best method to obtain information on the highly variable land surface emissivity under precipitating situations?

Three main focus areas were addressed over the past year and are summarized below.

Improved TRMM 2A12 Rain Over Land

After the 2008 PMM Science Team meeting, the PI's were charged with finding a short-term solution to the current 2A12 rainfall over land warm season bias, which has been well documented and needed to be addressed in time for the next TRMM version (V7). As such, we agreed to solving this problem (without a total overhaul to the algorithm) delivering the algorithm/code by March 2009.

It was discovered that one of the main culprits in this bias is in the convective-stratiform (CSI) separation. Additionally, the TB to rain rate relationships were not robust. The new algorithm, created from nearly 10-years of TMI and PR matchups, abandons the cloud resolving model data base and simply uses an improved CSI and TB to RR relationship. It has been delivered to NASA where it is undergoing testing. The figure below summarizes the TMI – PR biases (current – top; new- bottom) based on the entire TRMM record. As can be seen, the warm season bias has been substantially reduced. Remaining biases are partially attributed to inadequate land surface screening which we are starting to address (next section). The results have been summarized in a paper by Gopolan et al. (2009).



Surface Characterization

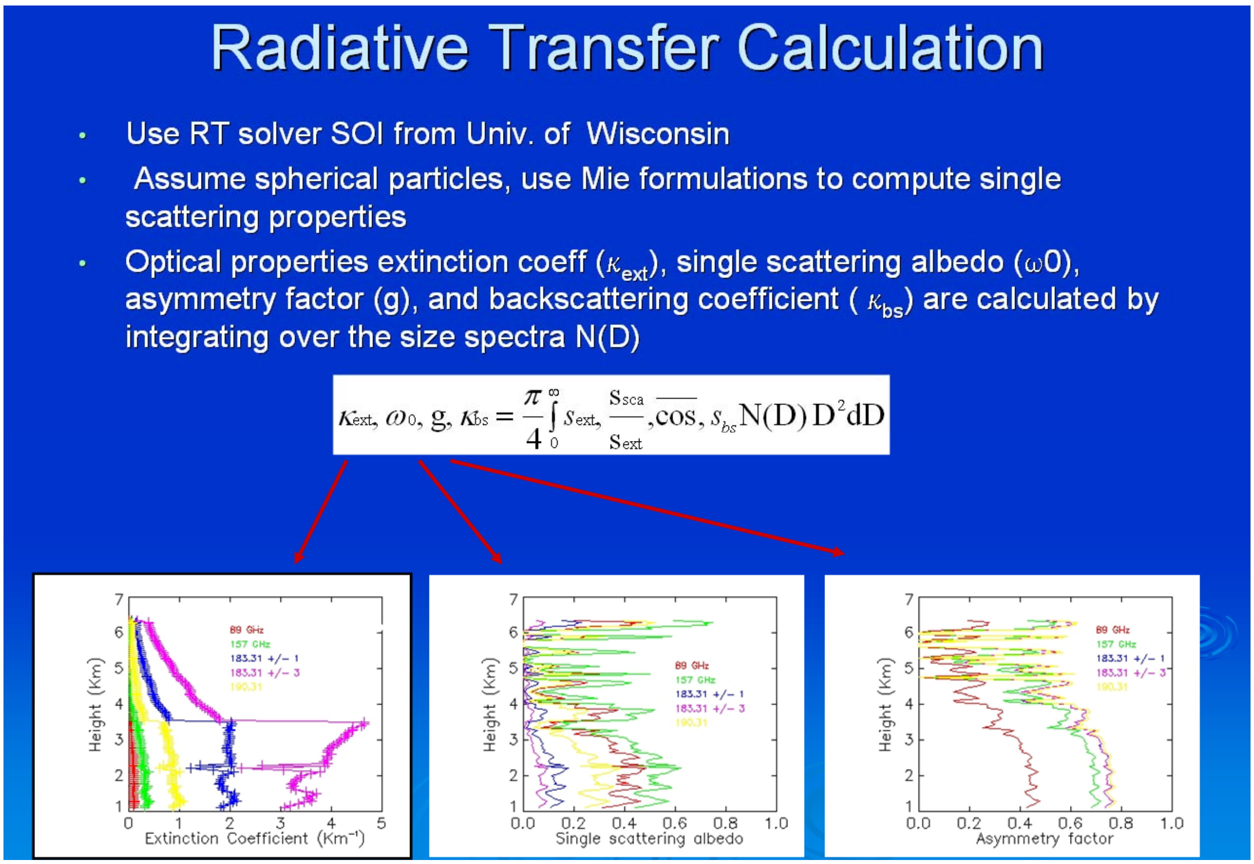
At the July 2008 PMM Science Team meeting, a new working group was established – The Land Surface Characterization Working Group (LSWG). The LSWG has met (in person and over phone) three times since then and have devised a simple emissivity intercomparison effort. Radiances from TMI, AMSU, SSMI, SSMIS and AMSR-E were extracted for 10 target areas across the globe (of varying surface characteristics, e.g., snow, desert, rain forest, etc.). Additionally, cloud mask data, NWP model fields, and land surface model parameters have also be extracted for these targets.

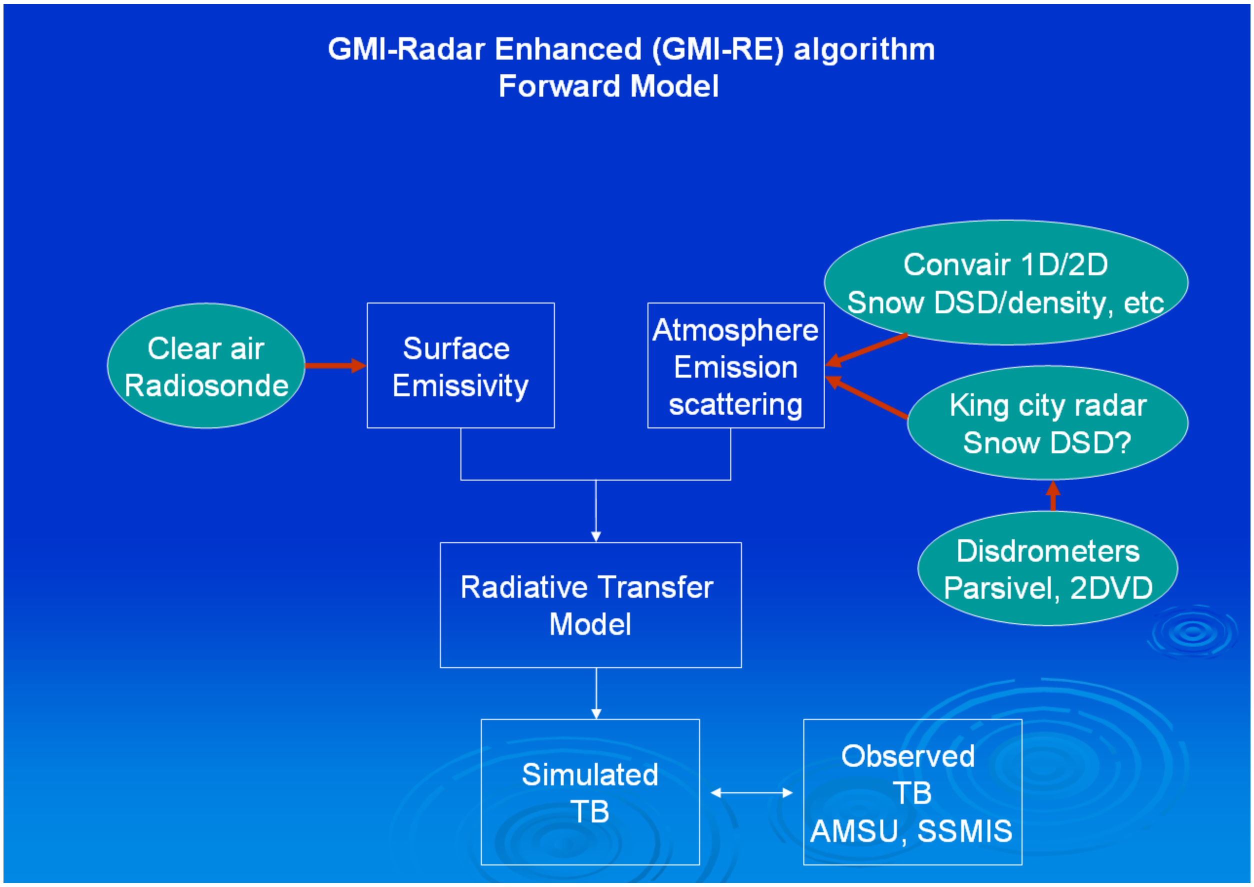
The exercise is for each participant to retrieve emissivity for these targets and sensors and frequency ranges so that we can compare and see their similarities and differences.

Preliminary results will be presented at the next PMM science team meeting (October 2009, Salt Lake City, UT).

Radiative Transfer in Snowing Atmospheres

Extensive work continues on using the C3VP field campaign data to extract precipitation related parameters in snowing atmospheres that are critical to radiative transfer modeling, in particular, to frequencies at and above 85 GHz. The figures below illustrate some of these parameters and summarize how this data is being used.





This tedious effort is finally starting to pay dividends, as our simulations are starting to get closer to the actual satellite measurements (summarized in the table below). The residual differences are being investigated but are most likely attributed to errors in the water vapor profiles used. Once we are confident in the model is working properly, a larger set of simulations can be generated using other input such as NWP model fields.

Relevant Meetings Attended

- 2008 PMM Science Team Meeting (Ft. Collins, CO, July 2008)
- GPCP Working Group on Data Management (Hong Kong, China, September 2008)
- 4th Workshop of the International Precipitation Working Group (Beijing, China, October 2008)
- GPM L2 algorithm planning meeting (Greenbelt, MD, January 2009)
- GPM Land Surface Working Group meeting (College Park, MD, January 2009)

- 2009 JCSDA Annual Workshop (Linthicum, MD, May 2009)
- 2009 EGU Annual Meeting (Vienna, Austria, May 2009)

Collaborations

We continue to collaborate with our NOAA colleagues on the PMM Science team. This includes the production, delivery and evaluation of NOAA POES AMSU/MHS based L2 precipitation estimates to P. Xie, who uses such data as input to CMORPH. Additionally, C. Williams has been extremely helpful in providing insight to the use and interpretation of the C3VP and HMT specialized radar and profiler data sets which is vital to our understanding of winter season cloud microphysical processes. We also offer guidance and interpretation of TRMM L2 rainfall over land data sets to R. Kuligowski who is using such data to help calibrate his SCAMPR technique.

Our collaborations also extend out to several other members of the PMM Science Team. Rather than list individuals, participation on the following PMM working groups is noted:

- Canadian CloudSat and Calypso Validation Project (C3VP) working group
- Precipitation detection working group
- Land surface characterization working group
- L2 algorithm working group
- Drop size distribution working group

Finally, both PI's participate with NASA on several extramural activities related to PMM, including various advisory panels and planning committees.

Year 3 Plans

During the last year of the project, we plan to focus on the following:

- Complete the development of the radiative transfer model under snowing conditions through the continued use of SSMIS, AMSU, CV3P and HMT-West data.
- Explore the usefulness of incorporating land surface emissivity (from a variety of sources) into the land surface precipitation retrieval algorithm.
- Participate on the various PMM working groups, special PMM meetings, etc.
- Attend various GPM and TRMM related meetings (e.g., International workshop on emissivity, June 2009; PMM Science Team meeting, fall 2009, AMS Annual Meeting, January 2010).

Publications and Presentations

Gopolan, K., N-Y. Wang, R. Ferraro and C. Liu, 2009: Version 7 of the TRMM 2A12 Land Precipitation Algorithm. *To be submitted, Geophysical Research Letters.*

Wang, N-Y. and R. Ferraro, 2008: Improvement of cold season land precipitation through combined field campaign data and microwave high frequency RTM. PMM Science Team Meeting, Ft. Collins, CO, July 2008.

Wang, N-Y., R. Ferraro, C. Liu, D. Wolff, E. Zipser and C. Kummerow, 2008: The TRMM 2A12 land precipitation product – status and future plans. *In press, Journal of the Meteorological Society of Japan.*

Wang, N-Y., R. Ferraro and K. Gopolan, 2008: "Improvement of Cold Season Land Precipitation Retrievals through the use of Field Campaign Data and High Frequency Microwave Radiative Transfer Model". *Proceedings of the 4th Workshop of the International Precipitation Working Group, Beijing, China.*

Wang, N-Y., R. Ferraro and K. Gopolan, 2009 "Improvement of Cold Season Land Precipitation Retrievals through the use of Field Campaign Data and High Frequency Microwave Radiative Transfer Model". *Proceedings of the 2009 EGU Annual Meeting, Vienna, Austria.*

BUDGET SUMMARY (all numbers presented are in K)

Improved Microwave Precipitation over Land from TRMM through GPM Era

R. Ferraro and N. Wang

For period from July 1, 2007 – June 30, 2010

	Year 1	**Year 2**	**Year 3**
Direct Labor	0	0	0
Grant to CICS/Univ. MD[1]	135	139	140
NOAA Equipment & Supplies	0	0	0
NOAA Travel[2]	2.7	5.4	9.1
STAR Tax (5%)	7.3	7.6	7.9
Total Costs	**145**	**152**	**157**

[1] Funding supports Co-PI Nai-Yu Wang in Year 1, Nai-Yu Wang and Kaushik Gopolan beginning in Year 2.
[2] Supports Co-PI Ferraro for travel to PMM Science Team meeting and other relevant GPM/TRMM meetings